Partonic Collectivity at RHIC

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In high–energy nuclear collisions, the density is highest at the center of the created fireball, and is vanishing at the boundary. Hence, there is matter density gradient. Interactions among constituents will therefore push matter moving outwards. In case of frequent interactions, constituents will move outwards carrying the same velocity. In this way collective flow is developed in nucleus-nucleus collisions [1]. We would like to stress that $flow$ means the flow of matter and energy. It is independent of the type of constituents, whether partons or hadrons, or different species of hadrons. Hence by studying collective motion of hadrons emerging in the final state, one might be able to extract information of early collision dynamics [2, 3], when the system might reveal partonic degrees of freedom. This is independent of the details of either initial conditions and/or hadronization processes.

In order to characterize the transverse mass distributions, a hydrodynamically motivated fit is often used [4]. This allows to disentangle the collective motion, quantified by the transverse radial flow velocity $\langle\beta_T\rangle$, from thermal random motion measured by the temperature parameter $T_{\rm fo}$. In Figure 1, we show the derived 1–σ (dashed lines) and 2–σ (solid lines) contours for these parameters, extracted from those fits. The results for π, K and p, are numbered from 1 (most central) to 9 (most peripheral) $Au+Au$ collisions [5] and p+p collisions. Results for the multi-strange hadrons ϕ and Ω are shown in the top of Fig. 1 for most central $Au+Au$ collisions only.

As the collisions become more and more central, the bulk of the system dominated by the yields of π, K, p appears to be cooler and develops stronger collective flow, representing a strongly interacting system expansion. At the most central collisions, the temperature parameter and the velocity are $T_{\rm fo} \sim 100$ MeV and $\langle\beta_T\rangle \sim 0.6$(c), respectively. On the other hand, for the same collision centrality, the multi-strange hadrons ϕ and Ω freeze-out at a higher temperature $T_{fo} \sim 170$MeV, close to the point at which chemical freeze-out occurs [6]. A similar behavior was also observed in $Au+Au$ collisions at $\sqrt{s_{\rm NN}}$ = 130 GeV [7].

Multi-strange hadrons might have smaller hadronic cross sections[8] and therefore decouple from the fireball early, perhaps right at the point of chemical freeze-out. This would explain the low $\langle\beta_T\rangle$ and higher temperature parameter from the fit, see Figure 1. Most importantly, the finite value of $\langle\beta_T\rangle$ therefore must be cumulated prior to hadronization - via partonic interactions.

Summary: We performed the analysis of the transverse momentum spectra for several identified hadrons. We find that multi-strange hadrons ϕ and Ω freeze-out at a higher temperature and smaller collectivity. The non-vanishing collectivity is expected to be developed through the early partonic interactions in central Au + Au collisions at RHIC.

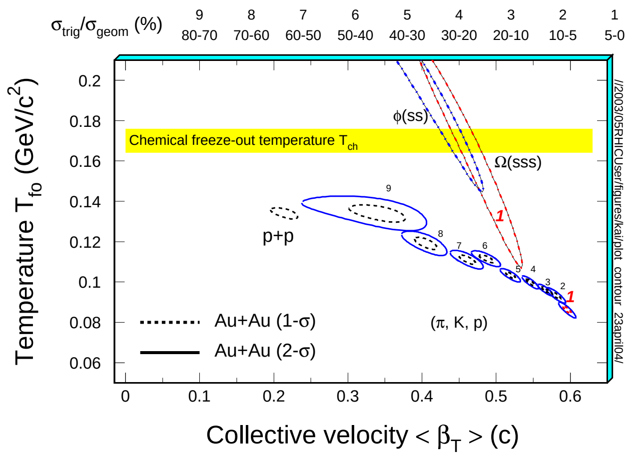

FIG. 1: 1–σ (dashed lines) and 2–σ (solid lines) contours for the transverse radial flow velocity $\langle\beta_T\rangle$ and the kinetic freeze-out temperature parameter $T_{\rm fo}$ derived from hydrodynamically motivated fits to identified particle spectra. The results for π, K and p, are numbered from 1 (most central) to 9 (most peripheral) $Au+Au$ collisions [5] and p+p collisions at 200 GeV. Results for the multi-strange hadrons ϕ and Ω are shown in the top for most central $Au+Au$ collisions only. The numbers at the top indicate the collision centralities.

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